Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Environmental Sciences 16 (2012) 138 – 144

Procedia Environmental Sciences

The 7th International Conference on Waste Management and Technology

Experimental research on gas production with single material waste

Haiyan Wang*, Lei Zhang, Shuiyuan Cheng, Tian Han

College of Environmental and Energy Engineering , Beijing University of Technology,Beijing 100124, China

Abstract

To study the effect of biogas production with a single component in the waste, the phenomena of biogas production with the groups of fat powder, cellulose powder and protein powder inoculated respectively in activated sludge from Liu Minying biomass pool and Xiao Hongmen Sewage Plant were observed simultaneously. Six reactors in total were settled. Gas production and the component of the biogas were monitored by GC everyday. Three single materials and the sludge were inspected with infrared spectrometer from the beginning of the installment of the reactors. The results of the experiments show that cellulose powder has the best ability on the respect of methane production, and fat powder is worse than cellulose powder but better than protein powder. On the respect of hydrogen production, protein powder is the best and the other two materials produce gas without hydrogen at all. Compared with sludge from the two different origins, sludge from Liu Minying biomass pool is better both on methane and hydrogen production. The difference of sludge FTIR figures between Liu Minying biomass pool and Xiao Hongmen Sewage Plant can explain this to some degree.

Keywords: single material waste; activated sludge; hydrogen production; methan production

1. Introduction

At present, with the great economic development, the demand of energy is getting more and more emergency all over the world. Due to this fact, renewable energy (Nicholas Apergis et al., 2011; Zhijie Gao, 2011) would play a more important role in the future. According to the "Twelfth Five-Year Plan of Renewable Energy Development" in China, the proportion of renewable energy consumption will be

* Corresponding author. Tel.: 86-10-67391659;
E-mail address: why@bjut.edu.cn

doi:10.1016/j.proenv.2012.10.019

account for more than 9.5% of all energy consumption in 2015. The usage of biomass will replace nearly 50 million tons fossil energy in 2015. In 2010, this number is already 20 million tons.

Most of the biomass is obtained from municipal wastes. The biogas such as methane and hydrogen is produced by wastes fermentation. Thus the technology of biogas production has received special attention. Compared with its clean producing course and without consuming mineral resources, more and more researchers (Yang Li et al., 2008; Yang Bojing et al., 2008; Jihong Li et al., 2008; Yung-Chung Lo et al., 2009; Honghui Yang et al., 2010) have carried out extensive research in the field of biogas production technologies as well as disposing wastewater and solid wastes (Julia Sumiko Hirasawa et al., 2008; Jolanta Bohdziewicz et al., 2008).

The objective of this study was then to examine biogas production by anaerobic fermentation with single component waste. They were fat powder, cellulose powder, and protein powder respectively. Each group was inoculated with activated sludge which were obtained from Liu Minying biomass pool (LMy) and Xiao Hongmen Sewage Plant (XHm) in Beijing, China. Therefore six groups were observed simultaneously. In order to understand the phenomenon of biogas production with different substrate, Fourier Transform Infrared Spectrometer (FTIR) was used to inspect the construction of the sludge at last.

2. Materials and Method

2.1 Materials

2.1.1 Fermentation material

The producing factories of the materials put in each reactor were listed in table 1.

Table 1 The producing factories of the material put in each reactor

	Material	Producing factory
1	Fat powder	Feed Co., Ltd. Shijiazhuang Benniu
2	Cellulose powder	Tianjin Guangfu Fine Chemical Research Institute
3	Protein powder	Zhucheng Xingmao Corn Developing Co, Ltd.

2.1.2 lnoculums

Activated sludge was collected from Liu Minying biomass pool (LMy) and Xiao Hongmen Sewage Plant (XHm) in Beijing, China. They were inoculated in each reactor. Their characteristics were listed in table 2 below.

Table 2 Characteristics of Activated Sludge

	Collection place	TS(g/L)	VS(g/L)	pH value
1	Liu Minying biomass pool(LMy)	78.807	60.592	7.1
2	Xiao Hongmen Sewage Plant(XHm)	30.076	20.64	7.1

2.1.3 Experimental device

Experimental device diagram was showed in fig. 1. One kind of material and sludge was put in one bottle, after that it was sealed with a rubber cap on the top of the bottle. A plastic graduated tube was

connected with the reactor in order to collect the biogas and record the volume of it. There were six bottles as a total settled and all of them were put in a constant temperature bath.

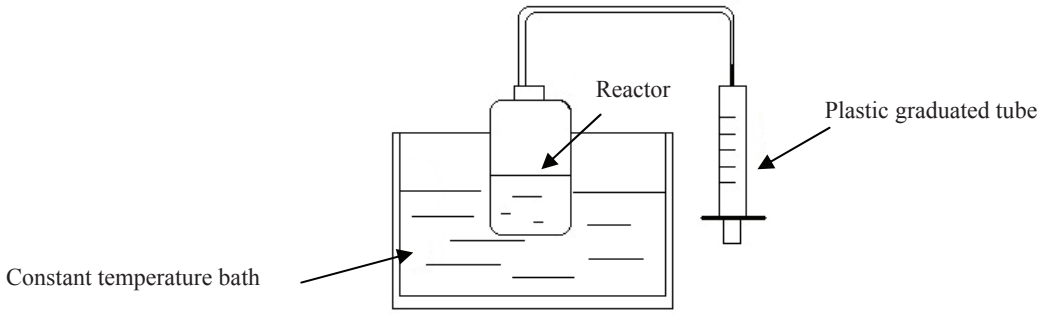

Fig. 1. Experimental device

2.2 Methods

2.2.1 Reactor fillings and reaction conditions

Table 3 Reactor fillings and the reaction conditions

No.	Substrate		Inoculums		Water	Reactor temperature
	Material	Quantity(g)	Sludge	Volume(ml)	(ml)	(℃)
1	Cellulose	30	LMy	100	50	35
2	Fat					
3	Protein					
4	Cellulose		XHm			
5	Fat					
6	Protein					

2.2.2 Analytical methods

TS: the active sludge was baked in the incubator keeping 105±5 centigrade to constant.

VS: the active sludge was burned in muffle furnace keeping 550±5 centigrade to constant.

Gas production inspection: plastic graduated tube connected with reactor shows daily volume of gas production. The gas component and the content were inspected with gas chromatography.

FTIR inspection: Infrared spectrometer (IRPrestige-21 made by Japan Shimadzu) was used to inspect the sludge structure. The analyzed sample should be dried and made pellet with KBr and scanned with the range of 400-4000cm^{-1}.

3. Results and discussion

3.1 The concentration of biogas production with different inoculums

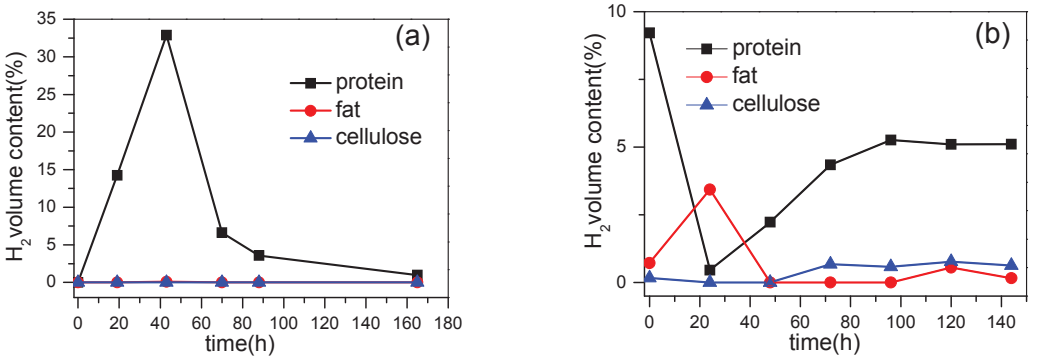

Fig.2. (a) Hydrogen production inoculated with LMy sludge (b) Hydrogen production inoculated with XHm sludge

Fig. 2 showed that on hydrogen production, protein had the best ability than fat and cellulose. The hydrogen volume content was 35% at most in the reactor with LMy sludge, and only 5% at most in the reactor with XHm sludge. Comparing with the reactors using fat and cellulose as substrate, protein was the best on the hydrogen production under the same conditions. Because the sludge was not taken any measures to strengthen the hydrogen bacteria, thus the hydrogen volume content was low. But the difference between the three materials was obvious.

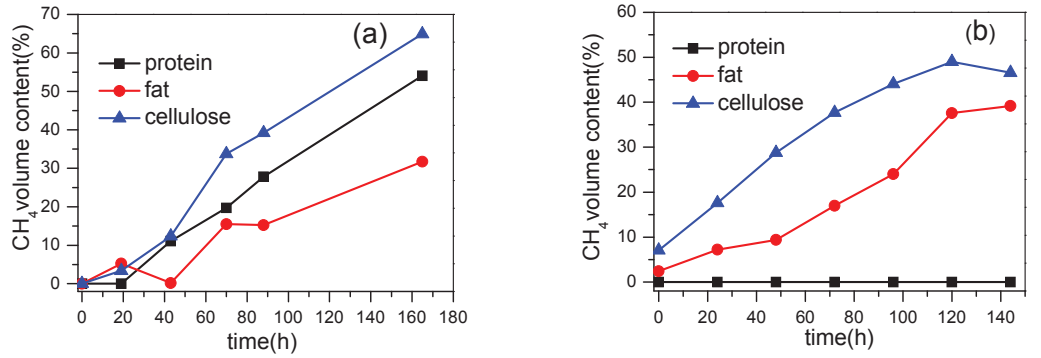

Fig. 3 . (a) Methane production inoculated with LMy sludge (b) Methane production inoculated with XHm sludge

Fig. 3 showed that on methane production, fat or cellulose was better than protein. In the three reactors inoculated with LMy sludge, the methane volume content all increased step by step and fat was the highest. Cellulose was lower than fat but higher than protein. In the three reactors inoculated with XHm sludge, the methane volume content of cellulose and fat increased step by step and cellulose was the highest. Methane was not found in the reactor filling with protein. Comparing with three materials, protein was the worst on the methane production under the same conditions. The better one between fat and cellulose on methane production were not sure according only to the volume content.

3.2 The cumulative biogas production with different inoculums

Fig.4 and fig.5 presented the cumulative biogas production with different sludge. In order to analyze which material was the best on biogas production, the volume of biogas production would be considered as another important characteristic.

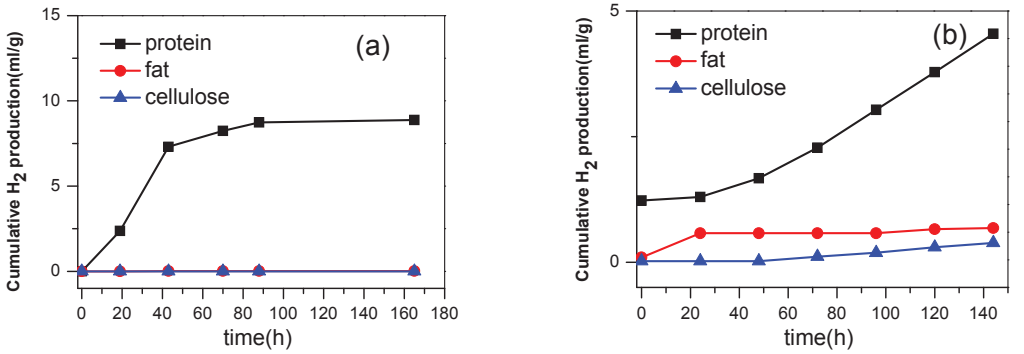

Fig.4. (a) The cumulative hydrogen production with LMy sludge (b) The cumulative hydrogen production with XHm sludge

Fig. 4 showed that on cumulative hydrogen production, protein was still the best among the three materials. The cumulative hydrogen production was about 10 ml/g at last in the reactor with LMy sludge, and about 5 ml/g in the reactor with XHm sludge.

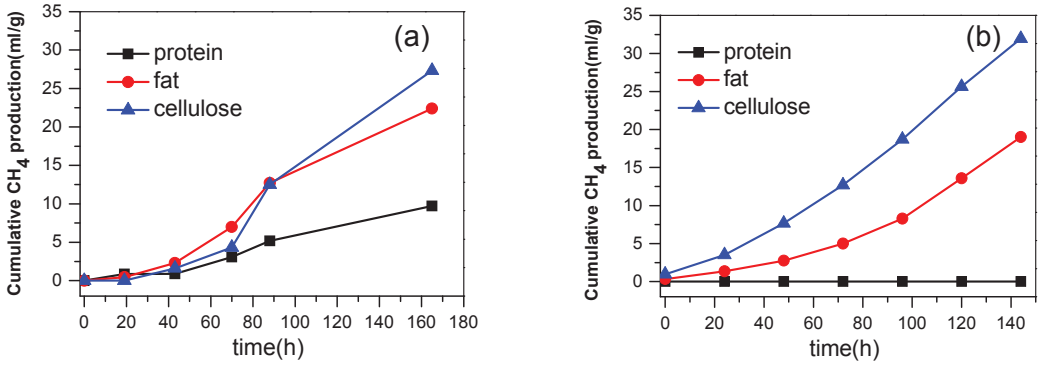

Fig.5. (a) The cumulative methane production with LMy sludge (b) The cumulative methane production with XHm sludge

Fig. 5 showed that on cumulative methane production, fat and cellulose were still better than protein. In the three reactors inoculated with LMy sludge, on the beginning period methane volume content all increased step by step and fat was the highest. Cellulose was lower than fat but higher than protein. In the three reactors inoculated with XHm sludge, the methane volume content of cellulose and fat increased step by step and cellulose was the highest. Methane was found in the reactor filling with protein. Comparing with three materials, protein was the worst on the methane production under the same conditions. The better one between fat and cellulose on methane production were not sure according only to the volume content.

3.3 The structure of different sludge

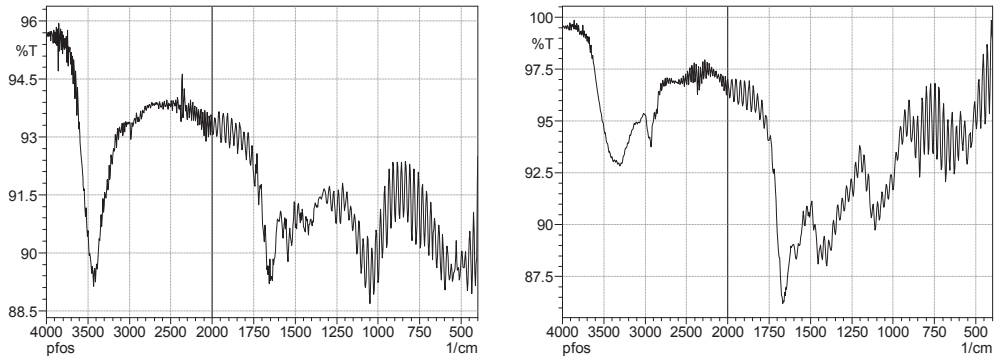

Fig .6 (a)FTIR figure of XHm sludge(b) FTIR figure of LMy sludge

Comparing with fig.2 to fig.5, the difference of biogas production inoculated with different sludge can be seen. The volume content of methane and hydrogen from LMy sludge was all higher than from XHm. On the respect of methane production, fat was the best and cellulose was worse than fat which inoculated with LMy sludge. But in the reactors inoculated with XHm sludge, the situation shows that cellulose was the best. It was just opposite from that one. To analyze this phenomenon, FTIR was used to inspect the construction of these two sludges.

From fig.6 can we see that there were some similarities on FTIR figure between XHm sludge and LMy sludge. On about 3420cm^{-1}, there all had a broad and strong peak that should be association hydroxyl group. On 2940~3000 cm^{-1}, there was s an asymmetrical stretching vibration peak of CH_2. On about 1650 cm^{-1}, there was a stretching vibration peak of C=O. On about 1570 cm-1, there was a peak of N-H bending vibration and C-N stretching vibration. On 1350~1460 cm^{-1}, there was a bending vibration peak of C-H. On 1020~1160 cm^{-1}, there was a stretching vibration peak of C-O-C which stands for polysaccharide.

Since there were all kinds of bacteria which were composed of protein, polysaccharide and nucleic acid in the sludge, the analysis of sludge FTIR figure above showed the characteristic peak of these materials. The sludge all had these characteristic peaks indicated that the component of bacteria in the sludge inoculated in the reactors was useful to the biogas production.

On the other hand, the different strength of some characteristic peak in two FTIR figures can explain the difference of biogas production.

4. Conclusions

As the substrate, protein has the best ability on hydrogen production. Cellulose or fat all have comparatively better ability on methane production than protein.

The sludge FTIR figure which has the characteristic peaks of protein, polysaccharide and nucleic acid indicate that the component of bacteria in the sludge inoculated in the reactors is useful to the biogas production.

Acknowledgement

This research was supported by Beijing Natural Science Foundation (No.8112009) and Beijing Academic Innovation Team(No.PHR20107105)

References

[1] Julia Sumiko Hirasawa, Arnaldo Sarti, Nora Katia Saavedra Del Aguila eta. Application of molecular techniques to evaluate the methanogenic archaea and anaerobic bacteria in the presence of oxygen with different COD: Sulfate ratios in a UASB reactor. Anaerobe 2008; 14:209-218.

[2]Honghui Yang, Liejin Guo, Fei Liu, Enhanced bio-hydrogen production from corncob by two-step process: Dark- and photo-fernentation. Bioresource Technology 2010; 101:2049-2052.

[3] Yang Li,Zhang Ting,Wang Zhi, etal. Anaerobic Fermentation of Biogas Using Cotton Stalk as raw material. International Conference on Biomass Energy Technologies. 2008;12:475-478.

[4]Jolanta Bohdziewicz, Ewa Neczaj, Anna Kwarciak. Landfill leachate treatment by means of anaerobic membrane bioreactor. Desalination, 2008; 221: 559–565.

[5] Jihong Li,Shi-guan Yang, Zheng Zheng, Influence Using Potato as Co-substrate on Acidification Fermentation And Biogas Yields of Spartina alterniflora. International Conference on Biomass Energy Technologies. 2008;12:436-442.

[6]Yang Bojing, Wang Hongtao, Lu Wenjing, Anaerobic digestion of single material waste for landfill conditions. Journal of Tsinghua Univ (Sci & Tech) , 2008; 9:1445-1449.

[7] Yung-Chung Lo, Yi-Chen Su, Chun-Yen Chen, etal. Biohydrogen production from cellulosic hydrolysate produced via temperature-shift-enhanced bacterial cellulose hydrolysis. Bioresource Technology 2009; 100:5802-5807.

[8] Zhijie Gao, Analysis of Biomass Energy Development in Heilongjiang Province according to the Reserve and Distribution of Biomass Resources. 2011 International Conference on Information Management, Innovation Management and Industrial Engineering. 2011:275-278

[9] Nicholas Apergis, Chris Tsoumas. Integration properties of disaggregated solar, geothermal and biomass energy consumption in the U.S. Energy Policy 2011; 39 :5474–5479.